



Simulering af laster på møller i wake

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Publication date:
2008

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Citation (APA):

Larsen, T. J., Aagaard Madsen, H., & Larsen, G. C. (2008). *Simulering af laster på møller i wake*. Paper presented at Vinddag 2008, Risø, Denmark.

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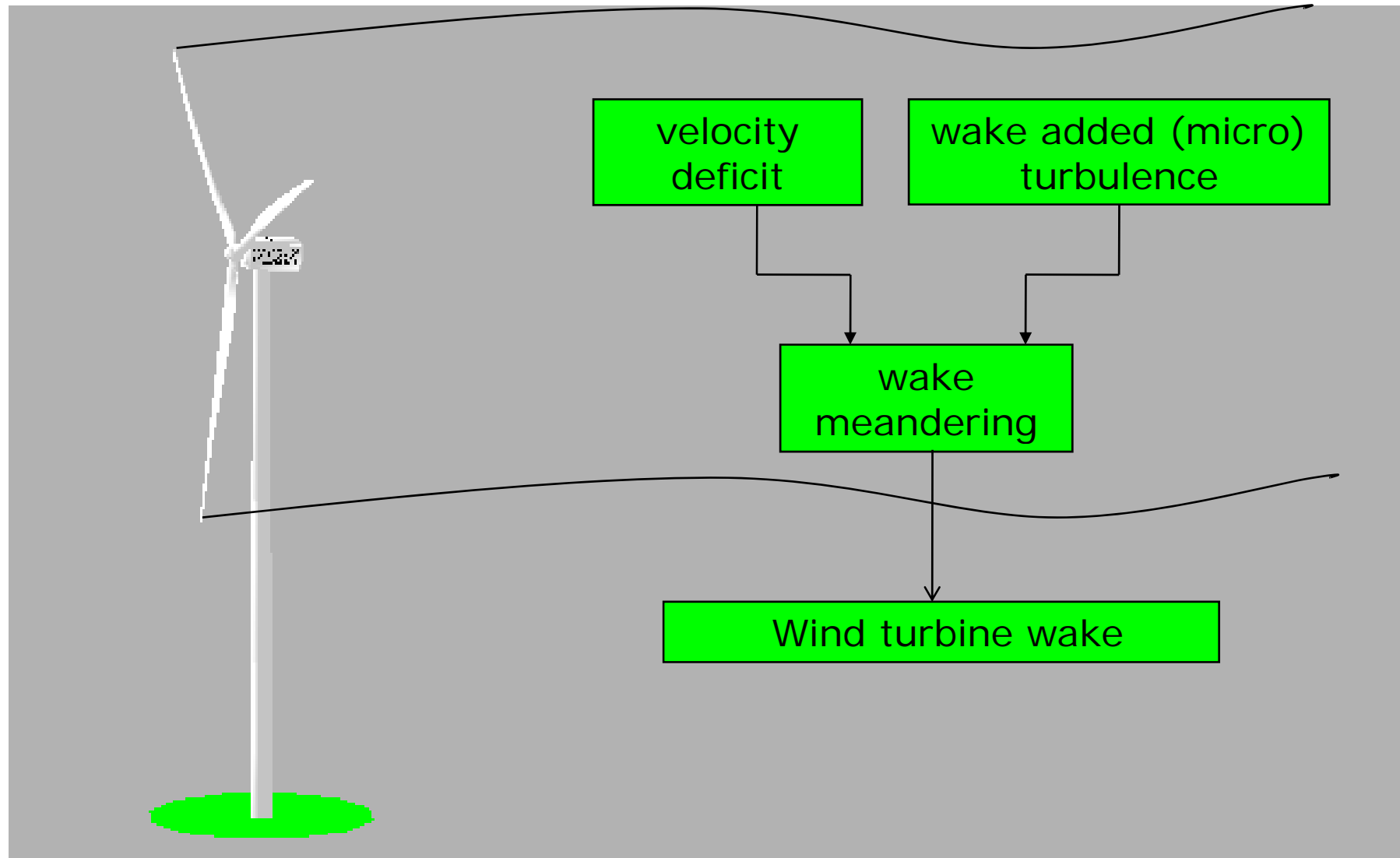
Simulering af laster på møller i wake

Dynamic Wake Meander (DWM) model
implementeret i HAWC2

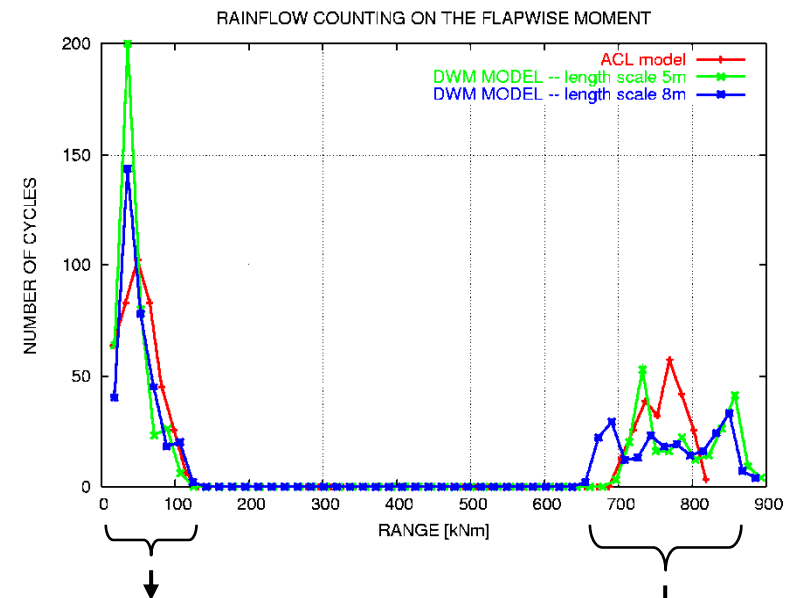
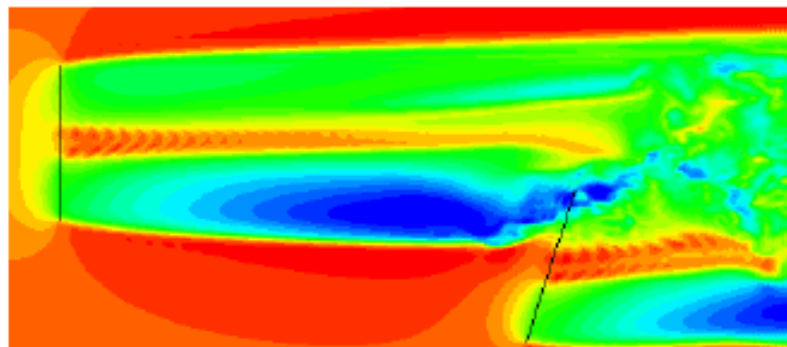
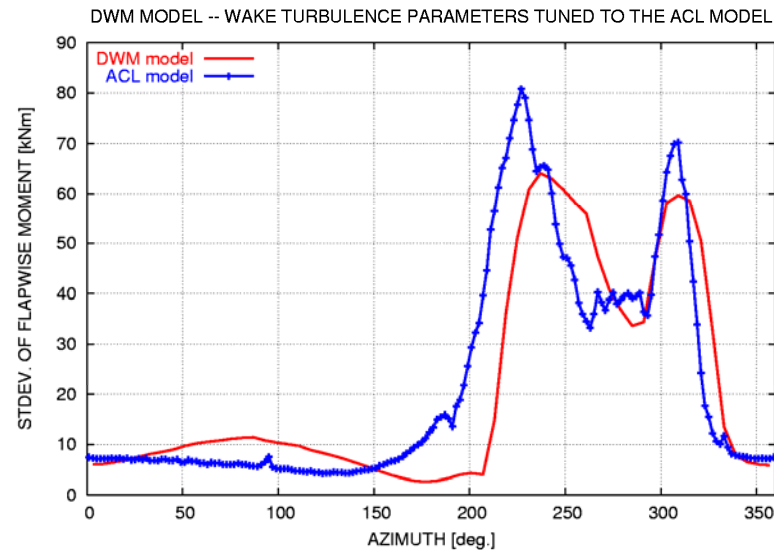
Torben J. Larsen, Helge Aa. Madsen, Gunner Larsen

Vinddag, Risø-DTU
25. November 2008

What is the wake?



Comparison of DWM and actuator line model no ambient turbulence

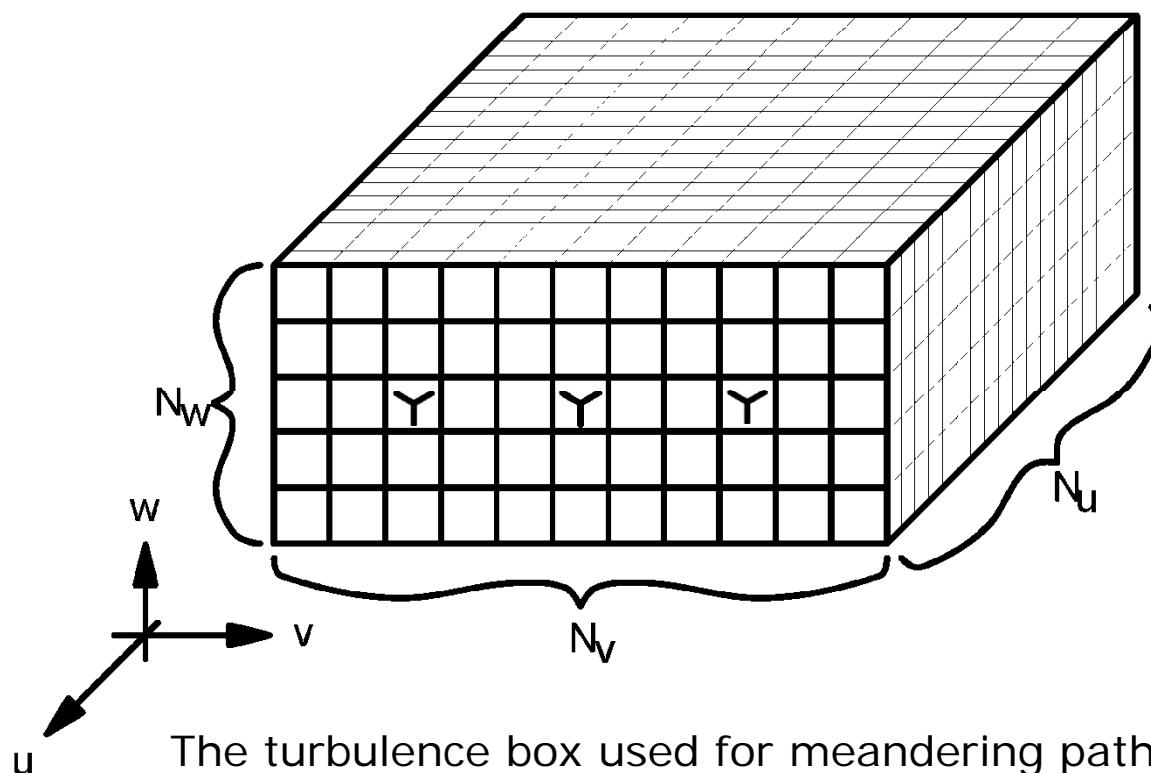


Influence of wake
added turbulence

Influence of
velocity deficit

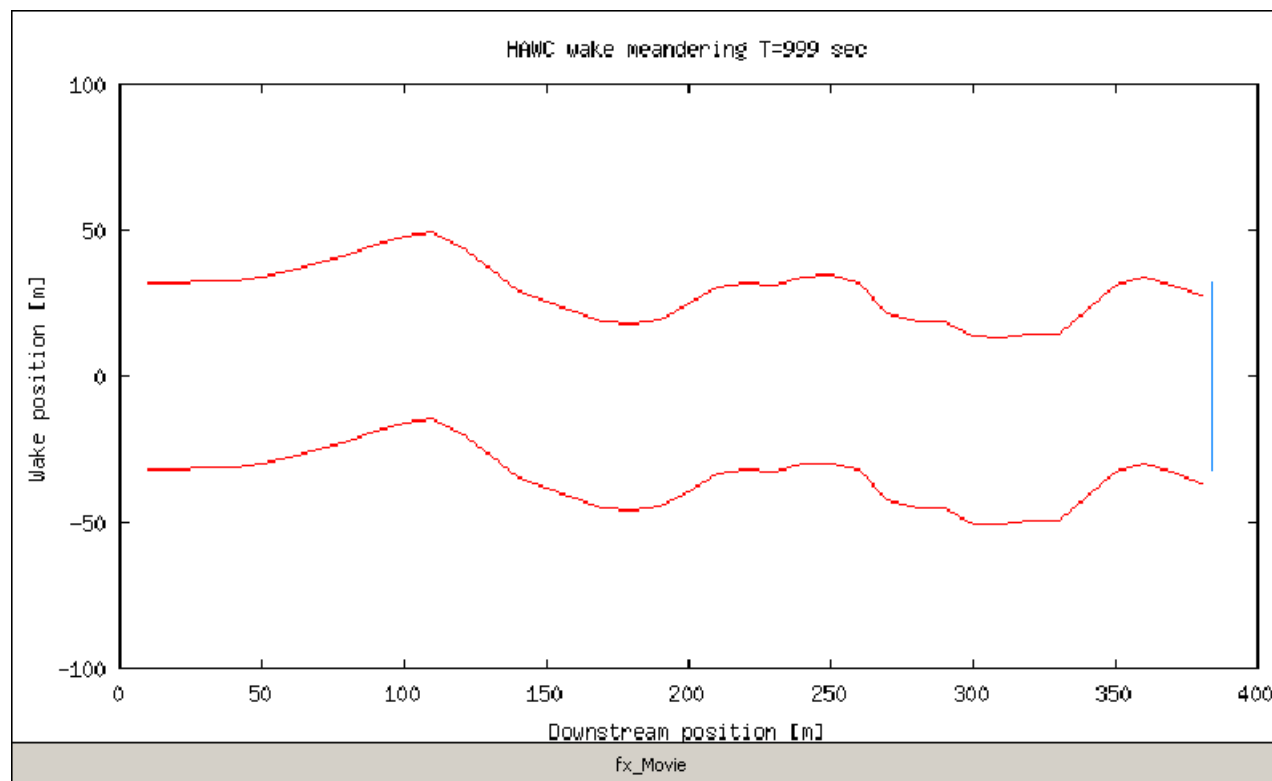
The Meandering

- A cascade of wake deficits are released from the upstream turbine
- Each deficit will be transported downstream affected only by ambient large scale turbulence (like smoke from a chimney)



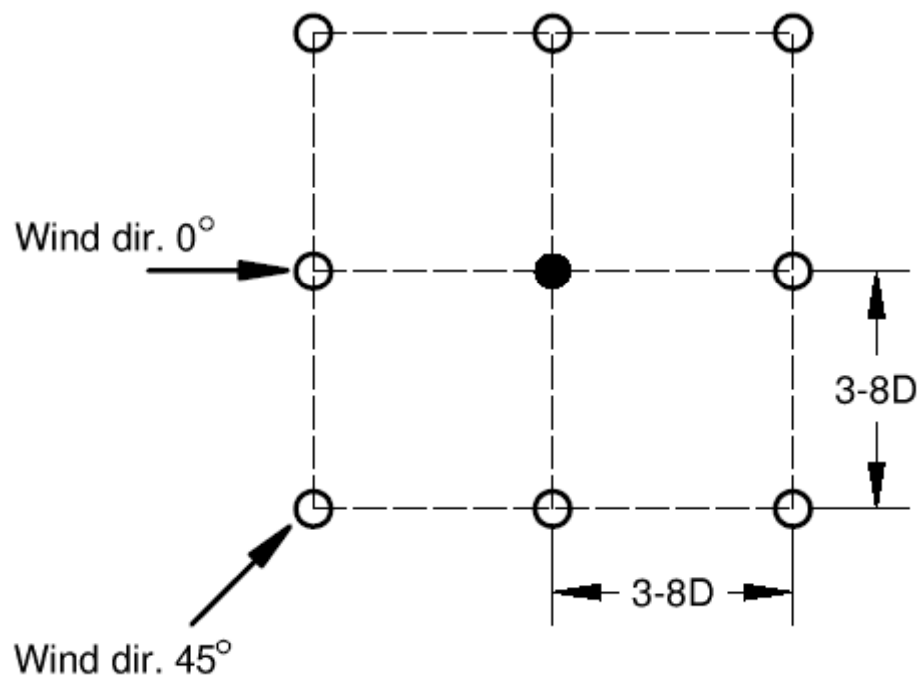
Simulation of wake deficit meandering

- A cascade of deficits are “released” at the upwind turbine
- The wake deficits are transported downstream affected by large scale lateral and vertical turbulence components.



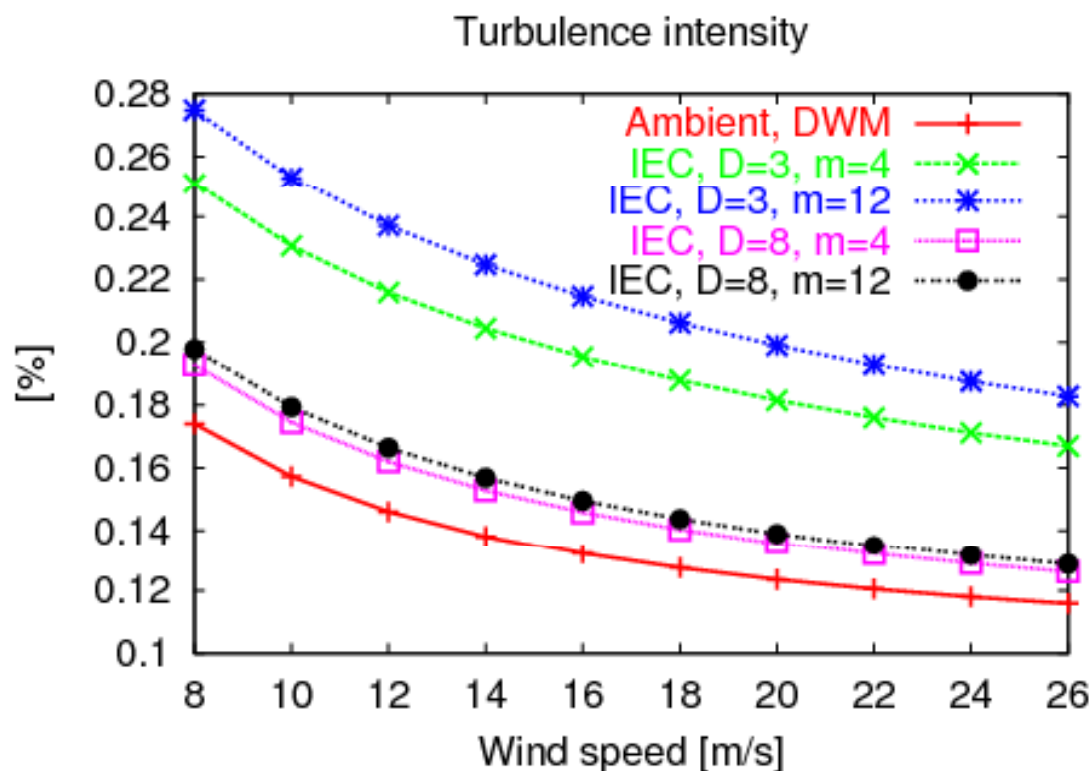
Load analysis of wind farm

- 2 MW pitch regulated turbine in a square park configuration
- 8 neighbouring turbines of same type
- Uniform wind direction distribution
- Wind terrain class IC (high mean wind, low ambient turbulence)



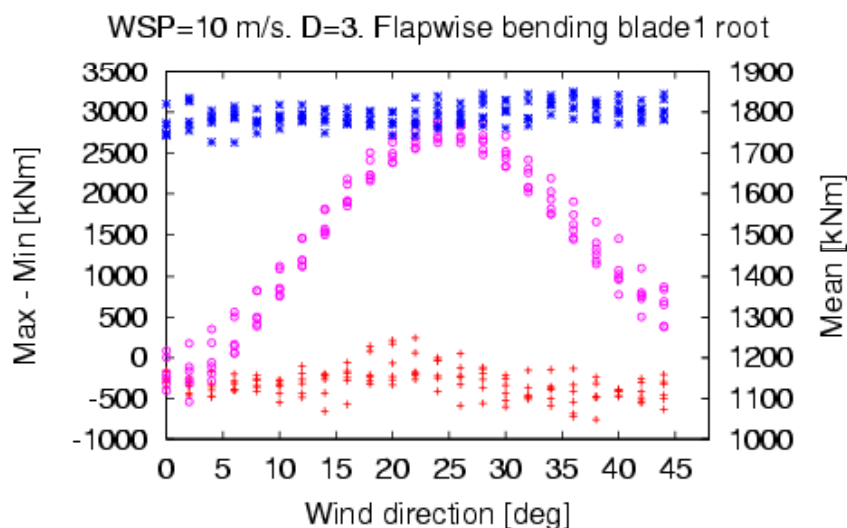
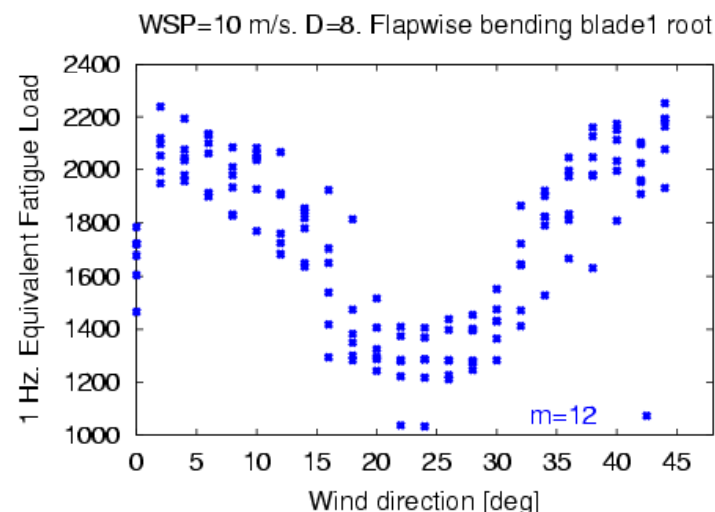
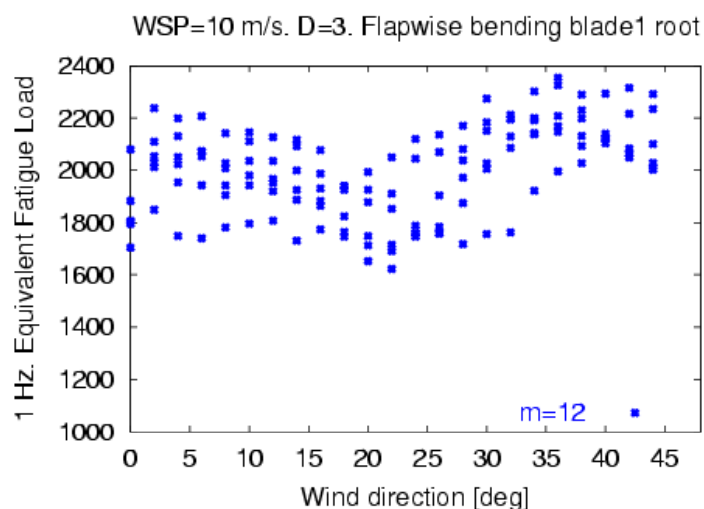
Simulation for each
2 deg using 6 seeds.
Total of 3312 DWM
10min. simulations

Used turbulence intensity for the IEC method

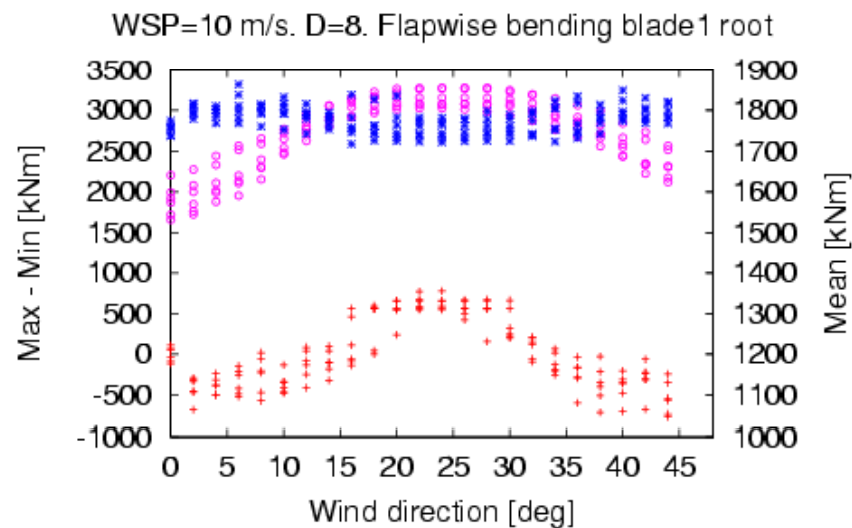


Ambient turbulence corresponds to class IC (high wind low turbulence)

Influence from wind dir. at 10 m/s: Flapwise blade bending

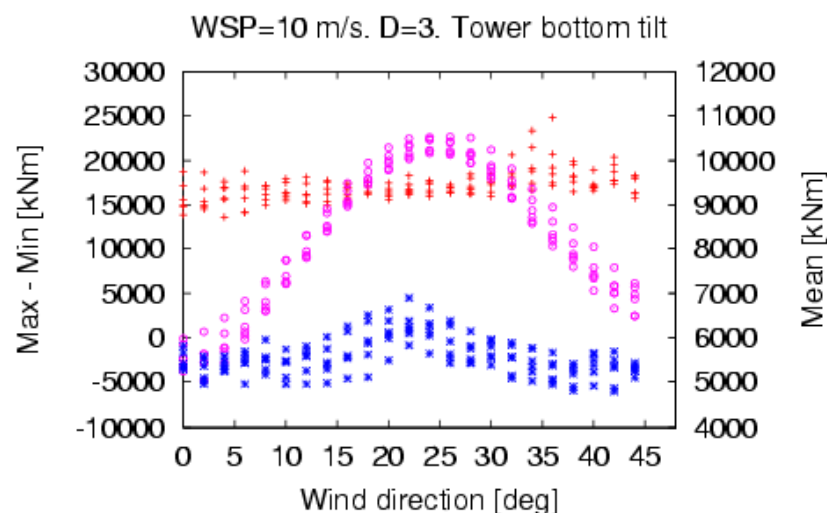
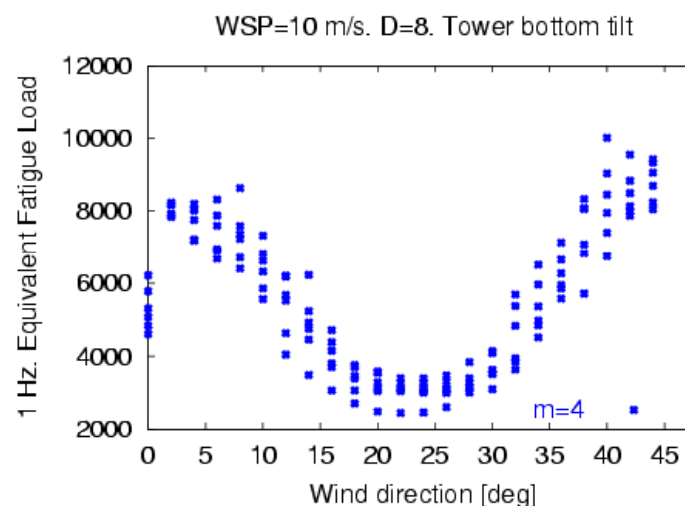
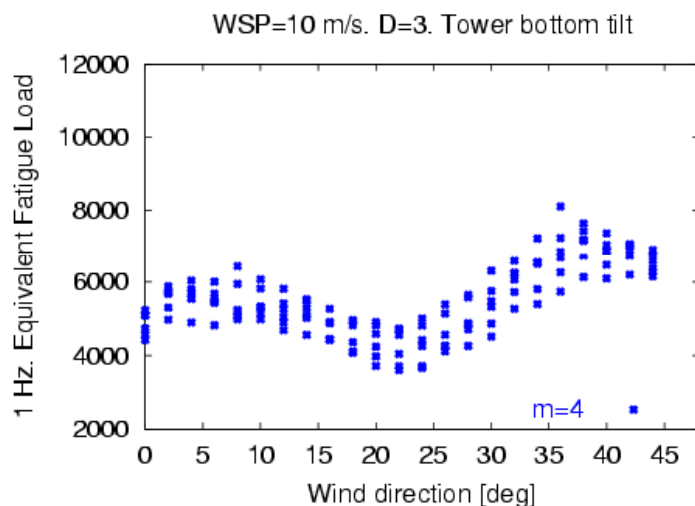


min + mean ° max *

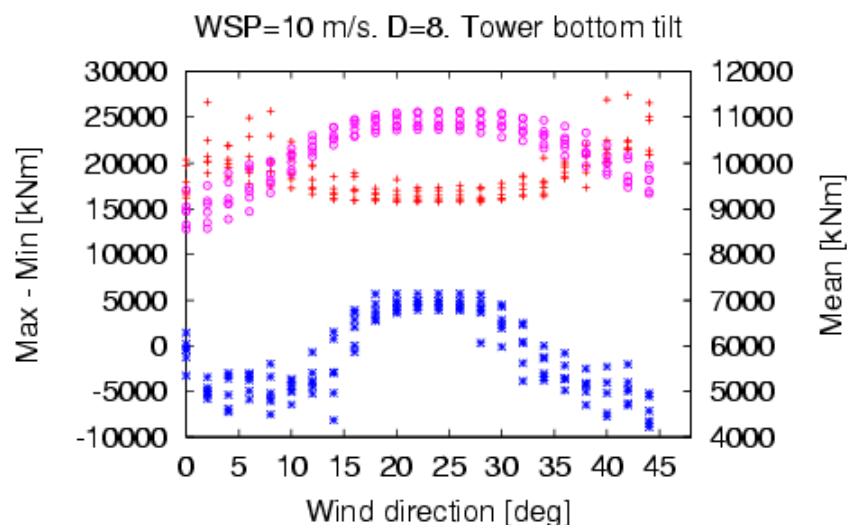


min + mean ° max *

Influence from wind dir. at 10 m/s: Tower bottom tilt

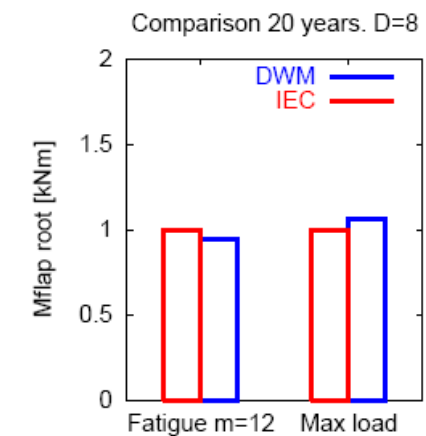
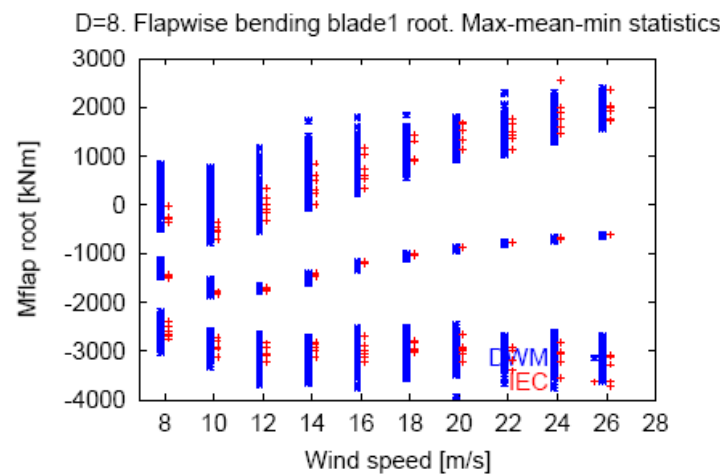
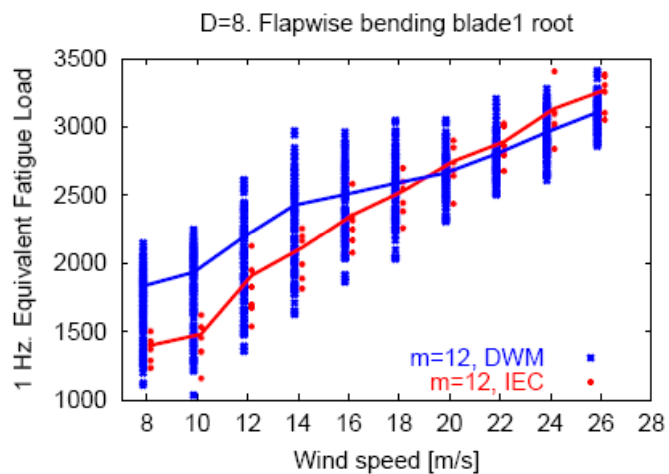
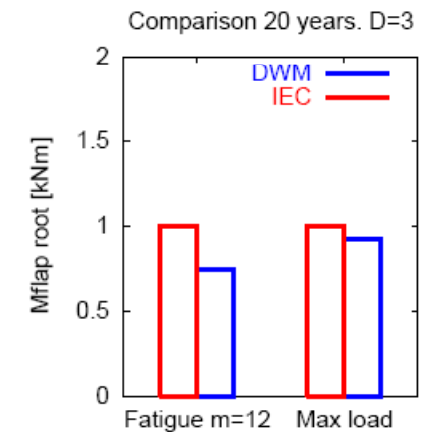
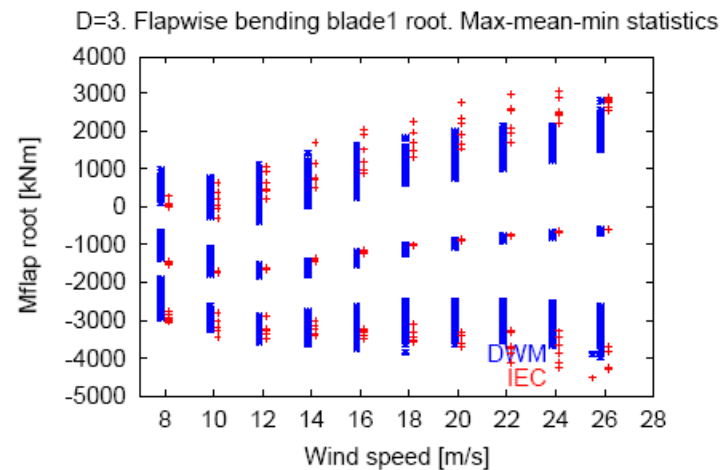
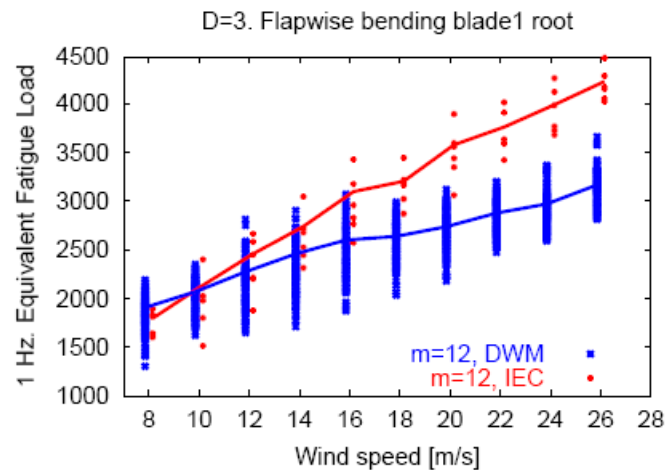


max + mean ° min x

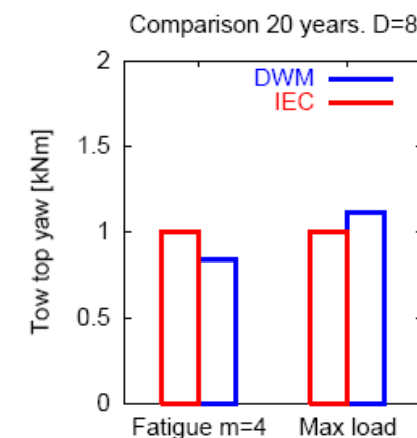
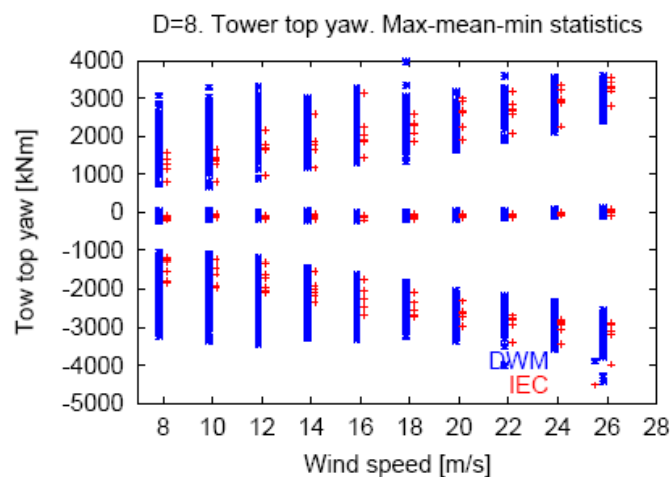
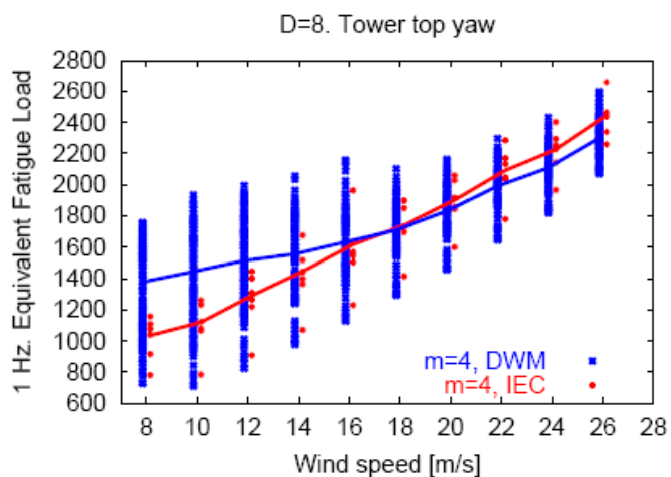
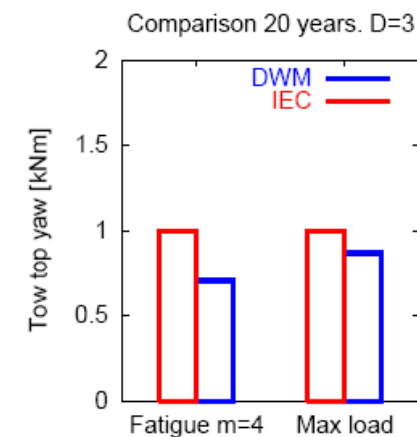
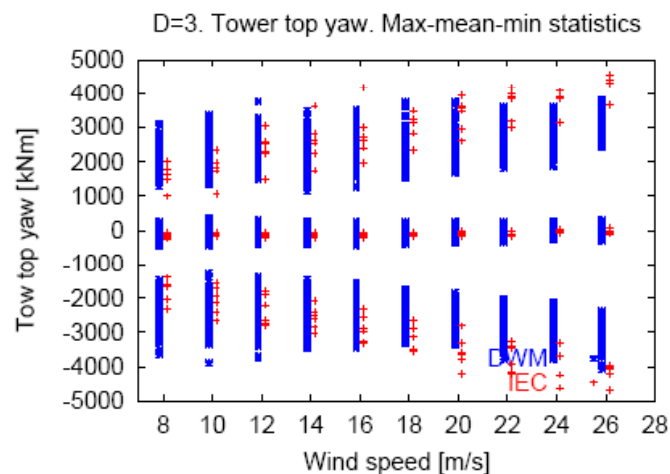
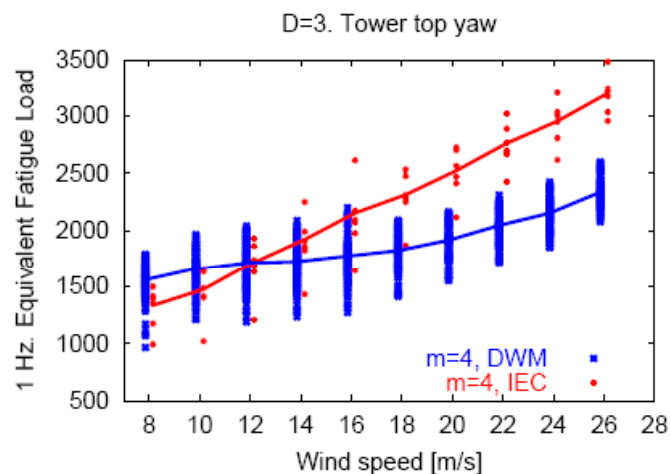


max + mean ° min x

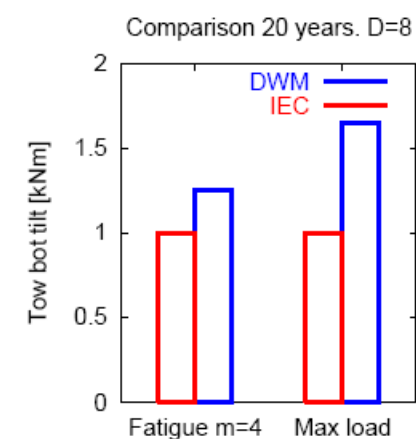
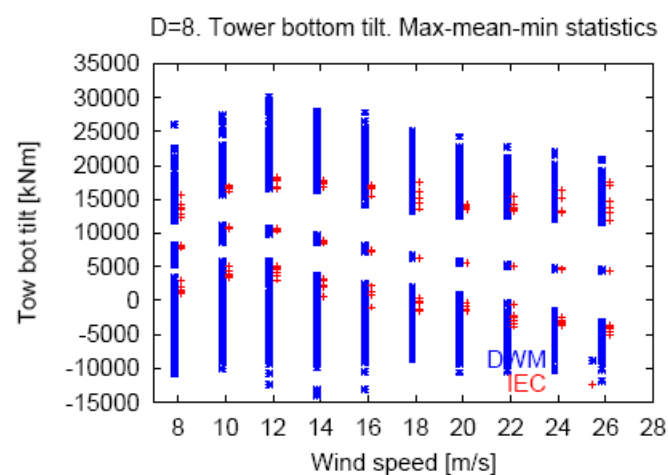
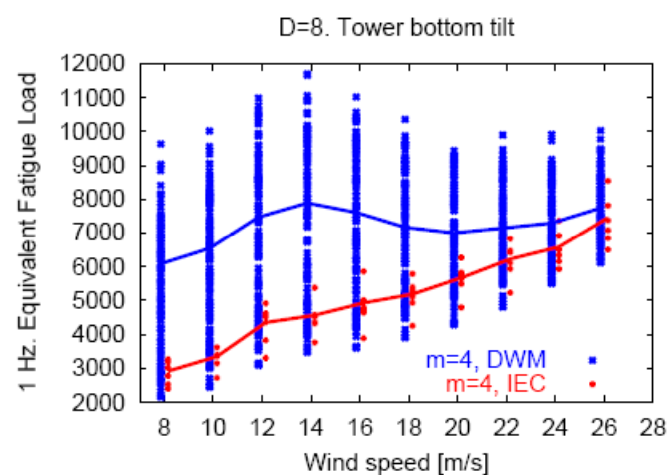
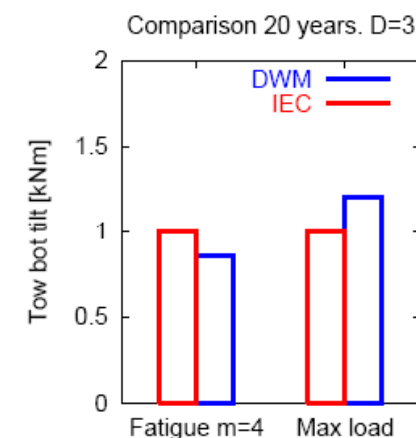
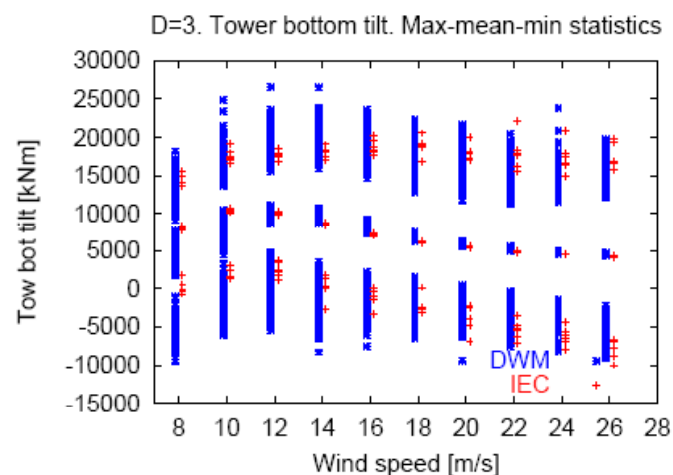
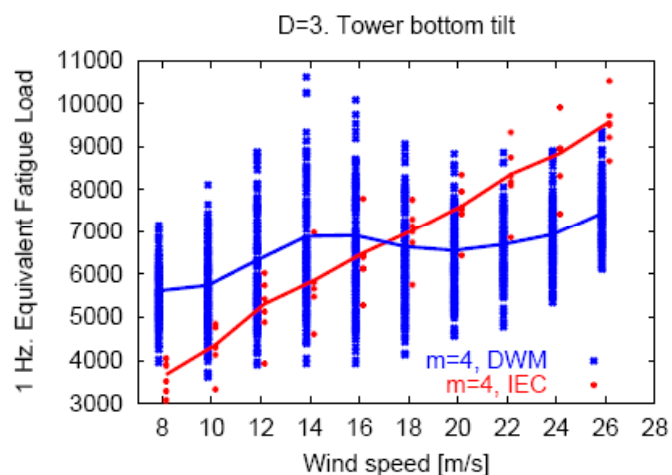
DWM – IEC Comparison 20 year production: Flapwise blade bending (pitching coo.)



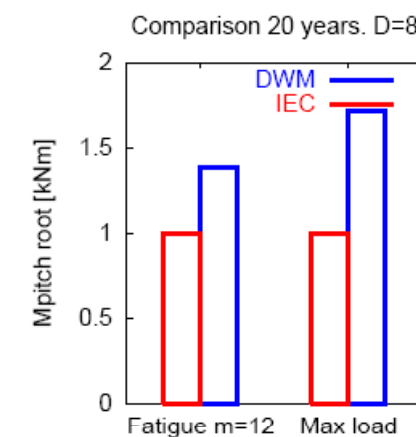
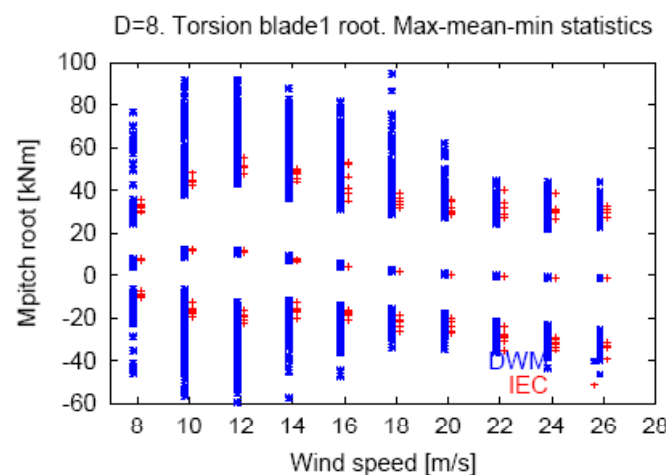
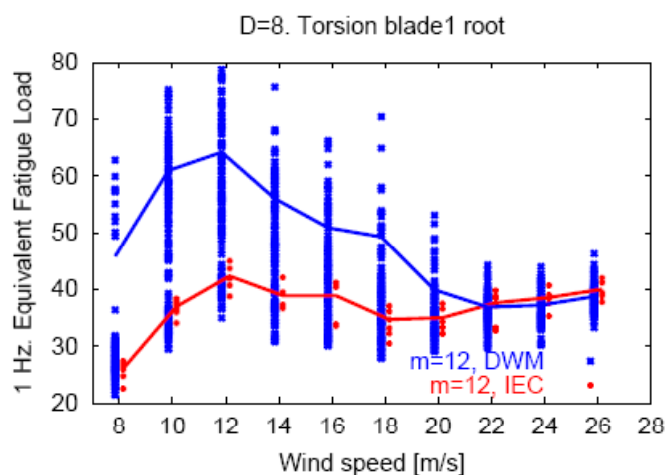
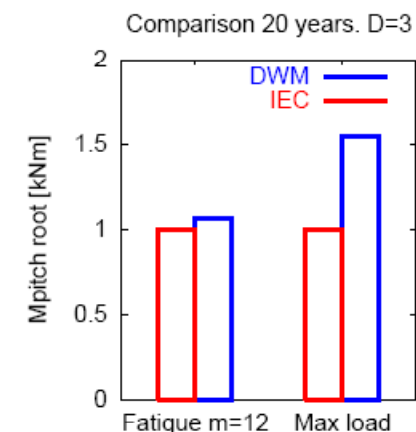
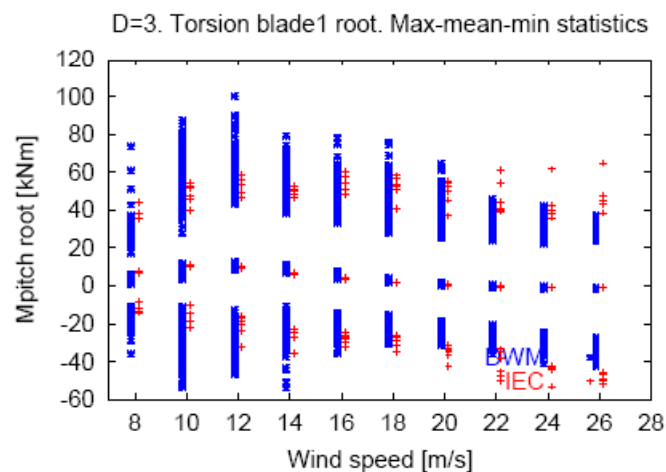
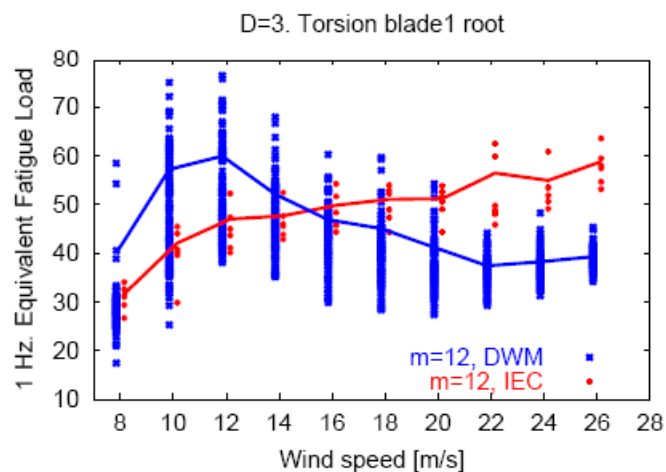
DWM – IEC Comparison 20 year production: Yaw bearing moment



DWM – IEC Comparison 20 year production: Tower bottom tilt



DWM – IEC Comparison 20 year production: Blade pitch moment at root



Conclusion

- New improved implementation of DWM model in HAWC2 demonstrated.
- In the used square grid park configuration the turbine *never experiences free flow direction at 3D spacing*.
- *Tower loads increase with increased row distance*. (At least up to 8 diameters spacing.) Possible explanation is the meandering effect.
- For 3D spacing the IEC loads are conservative regarding flapwise blade bending, for the yaw, driving torque and flapwise bending, whereas the loads on tower and blade torsion are non-conservative. Max load for tower +20% and blade torsion +55%
- For 8D spacing there is good agreement between the two models regarding yaw, driving torque and flapwise blade bending. A significantly higher load level is seen with the DWM model regarding tower loads and blade torsion. Fatigue +25% and max. load +60% for tower and blade torsion.